STATE OF VERMONT
PUBLIC SERVICE BOARD

Docket No. 6860

Petitions of Vermont Electric Power Company, Inc. ("VELCO") and Green Mountain Power Corporation ("GMP") for a Certificate of Public Good authorizing VELCO to construct the so-called Northwest Vermont Reliability Project, said project to include: (1) upgrades at 12 existing VELCO and GMP substations located in Charlotte, Essex, Hartford, New Haven, North Ferrisburg, Poultney, Shelburne, South Burlington, Vergennes, West Rutland, Williamstown, and Williston, Vermont; (2) the construction of a new 345 kV transmission line from West Rutland to New Haven; (3) the construction of a 115 kV transmission line to replace a 34.5 kV and 46 kV transmission line from New Haven to South Burlington; and (4) the reconductoring of a 115 kV transmission line from Williamstown, to Barre, Vermont

REBUTTAL TESTIMONY OF
GEORGE E. SMITH & W. STEVEN LITKOVITZ
ON BEHALF OF THE
VERMONT DEPARTMENT OF PUBLIC SERVICE

July 2, 2004

Summary: Mr. Smith's and Mr. Litkovitz's testimony: 1) discusses the question of whether NEPOOL and NPCC standards are commonly met in practice; 2) addresses the timing of the construction of the proposed 345 kV line; 3) comments on the likelihood of using the New Haven to Queen City corridor in the future for transmission at 230 kV or 345 kV; 4) examines the suitability of utilizing 230 kV in place of the proposed 345 kV circuit in the West Rutland to New Haven corridor; 5) comments on the analysis and conclusions offered by Addison County Regional Planning Commission witness Dr. Edward Fagen; 6) discusses the occurrence and significance of certain transmission contingencies on the VELCO system in April 2004; 7) comments on certain exhibits in the testimony of Gail Henderson-King; and 8) addresses various Board inquiries and record requests.

Rebuttal Testimony
of
George E. Smith & W. Steven Litkovitz

Identification of Witness and Qualifications, Mr. Smith

Q. Please state your name and position.

A. My name is George E. Smith. I am a professional engineer and consultant to the Vermont Department of Public Service (Department).

Q. Are you the same George E. Smith that previously submitted testimony in this proceeding?

A. Yes, I am.

Identification of Witness and Qualifications, Mr. Litkovitz

Q. Please state your name and position.

A. My name is W. Steven Litkovitz. I am an Electrical Engineer for the Vermont Department of Public Service.

Q. Are you the same W. Steven Litkovitz that previously submitted testimony in this proceeding?

A. Yes, I am.

Overview

Q. What is the purpose of your testimony?

A. In this testimony, we:

1) discuss the question of whether NEPOOL and NPCC standards are commonly met in practice;
2) address the timing of the construction of the proposed 345 kV line;
3) comment on the likelihood of using the New Haven to Queen City corridor in the future for transmission at 230 kV or 345 kV;
4) examine the suitability of utilizing 230 kV in place of the proposed 345 kV

circuit in the West Rutland to New Haven corridor;

5) comment on the analysis and conclusions offered by Addison County Regional Planning Commission witness Dr. Edward Fagen;

6) discuss the occurrence and significance of certain transmission contingencies on the VELCO system in April 2004;

7) comment on certain exhibits in the testimony of Gail Henderson-King; and

8) address various Board inquiries and record requests.

Q. Please summarize the primary conclusions reached in your testimony.

A. Our primary conclusions can be summarized as follows:

1) NEPOOL and NPCC standards are not "idealized" but rather are commonly met in practice.

2) The proposed 345 kV line should be constructed first among the major elements of the NRP.

3) It is unlikely that the New Haven to Queen City corridor would be used for future transmission at 230 kV or 345 kV.

4) Use of 230 kV in place of the proposed 345 kV in the West Rutland to New Haven corridor is not advised.

5) The analysis provided by Dr. Fagen is flawed, and his proposed alternative for the West Rutland to New Haven corridor is not viable.

6) Recent contingencies on the VELCO system underscore the need for transmission system improvements.

Use of NEPOOL and NPCC Reliability Criteria

Q. During the examination of Mr. Smith on his direct testimony in this proceeding, Chairman Dworkin requested information as to whether the reliability standards established by the New England Power Pool (NEPOOL) and Northeast Power Coordinating Council (NPCC or Council) are idealized standards or whether these are standards that are routinely and commonly met in practice. To begin with, can you explain the essential concept behind NPCC's standards?

A. Yes. The essential concept embraced by NPCC standards involves designing and operating power systems in a manner that maintains stable and secure operation, after experiencing a contingency, even at a time when the system is already in a degraded state from the loss of a major transmission element or other major resource. This concept is often referred to as the “N - 2 criteria.” This criteria, when observed over the last 40 years, has resulted in highly reliable operation of power systems within the NPCC region.

Q. What information can you provide regarding compliance with NPCC standards?

A. The NPCC membership agreement requires all NPCC members to design and operate their bulk power systems in full compliance with the NPCC Criteria Guides and Procedures. The NPCC’s membership includes, though is not limited to, ISO-New England and all of the transmission owners in the northeast United States, including VELCO. The NPCC also requires each member to notify the Council of any changes that are planned that could impact compliance with the standards.

Q. Does the NPCC enforce its standards?

A. Yes. The NPCC, through its Reliability Compliance and Enforcement Program, measures standards’ compliance and issues sanctions for any instance of non-compliance.

Q. What is the nature of the sanctions imposed by the NPCC?

A. Sanctions imposed by the NPCC are letters to appropriate parties. The parties that become addressees of a given letter depends on the level of non-compliance. As the level of non-compliance increases, the addressees increase in number and importance and range from functional group managers to State and Provincial regulatory agencies, to the NERC President, FERC, DOE, and State Governors and Legislatures.

Q. Are non-compliance letters effective sanctions?

A. Yes. The threat of non-compliance letters to various public officials appears to be effective. As evidence, we note that in recent years the number of non-compliance incidents have been reduced to zero. Starting in 2001, there have been zero operational and planning non-compliance incidents. Only a diminishing number of bulk power system protection maintenance incidents of non-compliance persisted through 2002. In 2003, there were zero incidents of non-compliance.

Q. What are the relevant NEPOOL standards and how do they relate to NPCC standards?

A. The relevant NEPOOL standards are specified in NEPOOL Planning Procedure 3, Reliability Standards for the New England Power Pool.[1] These standards essentially embrace all of the NPCC and North American Electric Reliability Council (NERC) standards, but go one step further with regard to applicability. While NPCC standards are applied to bulk power systems, and address "inter Area" impacts (here the NPCC uses the term "Area" to refer to major areas such as New Brunswick, New England and New York), the NEPOOL standards apply to much smaller geographic areas, i.e., to loads within New England, such as the area of northwest Vermont.

Q. What evidence can you point to suggesting that NEPOOL standards are not "idealized?"

A. NEPOOL, through its participants, supports the funding of projects required to bring member's transmission systems up to NEPOOL's standards. NEPOOL has agreed to support funding of the proposed NRP and to support the funding of other projects throughout the region. The willingness of NEPOOL's members to fund projects is evidence that the relevant NEPOOL standards are not simply idealized standards.

Timing of Construction of the Proposed 345 kV Line

Q. According to the testimony of Conservation Law Foundation witness Paul Chernick, the need for the construction of the 345 kV line from West Rutland to New Haven is not

[1]NEPOOL's Planning Procedure 3 states that "the interconnected bulk supply system shall be designed with sufficient transmission capacity to integrate all resources and serve area loads under conditions noted in sections 3.1 and 3.2" where Sections 3.1 and 3.2 define stability and steady state assessment contingency conditions. See VELCO Exhibit Planning - 9.

imminent. Do you agree with this assessment?

A. No. Mr. Chernick may have based his conclusion on the least cost planning sequence described in the prefiled direct testimony of VELCO's Planning Panel. (See Exhibit Planning - 6, "Northwest Vermont Reliability Project Critical Load Milestone Study.") This study assumes ideal conditions which allow for the deferral of the most expensive upgrades until last. However, this idealized sequence ignores real-world issues such as construction constraints, ROW acquisition delays, and the maintenance of system reliability during construction. These issues were addressed by VELCO in its overview of the actual proposed construction sequence, provided in the prefiled direct testimony of Ryan Johnson. (See Exhibit RJ-2, "Proposed NRP Construction Schedule.") This actual proposed construction sequence places construction of the 345 kV line as one of the first items in the project sequence.

Q. Please explain how system reliability would be enhanced by constructing the 345 kV line first.

A. During construction of the NRP, outages necessarily required of transmission lines and substations during the construction process weaken the transmission system, thereby degrading its ability to withstand contingencies. Construction of the West Rutland to New Haven 345 kV line early in the NRP construction sequence provides the following benefits:

1) Among the elements comprising the NRP, the 345 kV line is by far the single most important element in strengthening the system feeding northwest Vermont. This is due to the impedance reduction that results by extending 345 kV some 35 miles further north from West Rutland towards northwest Vermont. This extension would substantially enhance the ability of the transmission system to withstand contingencies that occur simultaneously with construction outages.

2) This line parallels the existing 115 kV path from West Rutland to New Haven thus enabling construction outages for line and substation work along this 115 kV path, including the work that would be required at the line's terminations at West Rutland and New Haven.

3) Should an extended outage of the Highgate Converter or the PV20 line or another major element occur in the near term, the added strength afforded by completing the 345 kV line early-on would provide the ability to withstand most, if not all, normal contingencies, depending on the load level at the time.

Q. Do you believe that the 345 kV line from West Rutland to New Haven should be constructed first?

A. Yes. We believe that in order to maximize operational reliability, minimize potential adverse impacts to Vermont's electrical customers during the construction and commisioning of the many NRP project elements, and enhance the ability to operate reliably should an important major outage occur, first priority should be given to completing the 345 kV line early on in the NRP construction sequence.

Potential for Upgrading the New Haven to Queen City Corridor to Higher Voltages

Q. During the direct testimony phase of this proceeding, concerns were raised that the transmission corridor from New Haven to Queen City could, at some time in the future, be upgraded to voltage levels above that of the presently proposed 115 kV. Do you believe that future upgrades to this corridor, for example to 230 kV or 345 kV, are likely?

A. No. At this time we can envision only two possible reasons for upgrading this corridor to higher voltages. Neither appears likely. The first possible reason would be to extend extra-high voltage, i.e., 230 kV or 345 kV, from New Haven into Chittenden County to help meet state-wide loads beyond 1200 MW. However, the Queen City substation is not in the path of possible future transmission upgrades under consideration by VELCO. Rather, the most likely scenario involves extending 345 kV from New Haven to a future VELCO Champlain substation[2] using the existing New Haven to Williston corridor. At Champlain, the 345 kV network could interface with eventual extensions of the 230 kV

[2]The site for a possible Champlain substation is on land owned by VELCO located just to the east of the VELCO Essex substation.

network which presently terminates at the Granite substation in Barre and at the Plattsburgh substation in Plattsburgh, New York. What is key to this scenario is that completion of the proposed NRP New Haven to Queen City 115 kV line could allow for the eventual removal of the existing 115 kV line from New Haven to Williston. With this line removed, the existing New Haven to Williston corridor, and a portion of the Williston to Essex corridor, could be used for a future 345 kV line from New Haven to Champlain thereby removing any need to utilize the New Haven to Queen City corridor.

The other possible reason for upgrading the New Haven to Queen City corridor to voltages above 115 kV would be to accommodate the siting of a large generation facility, perhaps on the order of 200 MW or more. We are not aware of plans for such a facility.

Suitability of Utilizing 230 kV in the West Rutland to New Haven Corridor

Q. During the direct phase of this proceeding, the issue of upgrading the West Rutland to New Haven corridor to 230 kV rather than 345 kV was raised. Do you believe that an upgrade to 230 kV from West Rutland to New Haven would be appropriate?

A. No. As discussed in Mr. Smith's direct testimony, an upgrade in this corridor to 230 kV rather than 345 kV would not be appropriate for the following reasons: First, if 230 kV is utilized, additional system reinforcements beyond those proposed for the NRP may be required to achieve a 1200 MW state-wide load serving capability. Second, utilizing 230 kV would require additional voltage transformation, from 345 kV to 230 kV, at the West Rutland substation. Upgrading the West Rutland substation to accommodate 230 kV would be costly, especially given existing geographic and space constraints at this site. Third, a 230 kV circuit would have higher impedance, and therefore higher losses, than a 345 kV circuit.[3] And fourth, use of 230 kV could limit the load serving capability of future system expansions.

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[3]The proposed construction at 345 kV utilizes bundled (two conductors per phase) 954 kcmil ACSR. A 230 kV configuration that would utilize this corridor's existing 115 kV structures would likely be limited to single 954 ACSR conductor per phase due to the mechanical limitations of these structures. (This 230 kV alternate would also require the addition of a new 115 kV circuit from West Rutland to New Haven.) The resultant losses on the 230 kV circuit would be over four times as great as the losses of a 345 kV circuit.

Q. After considering this issue further, are there other reasons why you believe that an upgrade to 345 kV is preferable over an upgrade to 230 kV for this corridor?

A. Yes. First, the lower impedance of 345 kV provides substantially more strength to northwest Vermont than could be obtained from a 230 kV circuit. This added system strength would enhance voltage stability and minimize the impact of contingencies. As a result, the severity of voltage dips and sags experienced by customers following contingencies would be diminished. The added system strength would also lower the likelihood of contingencies leading to generator trips and the momentary loss of the Essex STATCOM and the Highgate Converter.[4] The added stability provided to generation, the Essex STATCOM, and the Highgate Converter would lower the likelihood of multiple contingencies that could have severe area-wide impacts.

Second, the lower impedance of a 345 kV circuit would benefit loads in western and central Vermont. Specifically, an important contingency on the VELCO system is the loss of the 345 kV source from the south; particularly the loss of the 345 kV line from Vermont Yankee to Coolidge. In the event of this contingency, the lower impedance afforded by the 345 kV circuit from West Rutland to New Haven would provide a stronger connection to northern sources thereby benefitting loads in the Rutland and Middlebury areas.

Third, as discussed above, constructing the 345 kV circuit early-on in the NRP construction sequence provides reliability benefits to the system during construction of the other elements of the NRP. The higher impedance of a 230 kV circuit would diminish these benefits.

Q. In their prefiled testimony at answer 6, Gary Lange and Martha Redpath claim that “the existing 115kV line from New Haven to Williston could be upgraded to a 230 kV line to bring the necessary power to meet VELCO’s projected power needs in and along that

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[4]The Essex STATCOM and the Highgate Converter are devices that employ high power electronics which are vulnerable to a phenomenon known as “gate blocking.” Gate blocking is the interruption of the functionality of power electronics, due to transients and/or low voltages, which effectively removes the device from service.

existing corridor," and in response to discovery (IR DPS1-Lange/Redpath-4) they stated this claim is based on the Department's expert testimony. Similarly, in a motion filed by the Town of New Haven (New Haven) on March 9, 2004 in this proceeding,[5] at page 7, in the context of the possible use of a 230 kV circuit in place of the proposed 345 kV circuit in the West Rutland to New Haven corridor, New Haven states that Mr. Smith's "prefiled testimony and his live examination noted that the 230 kv line would use existing poles and the existing right-of-way." Are these statements accurate representations of the Department's testimony in this proceeding?

A. The statement by Gary Lange and Marcia Redpath is inaccurate and incomplete. The statement by the Town of New Haven is incomplete. In both his prefiled direct testimony and cross examination of March 5, 2004, Mr. Smith stated that while he believes that the existing 115 kV structures in the *West Rutland to New Haven* corridor could be upgraded to accommodate a 230 kV circuit, *construction of a new 115 kV circuit would also be required in this corridor.* As explained above, we do not believe that this is an appropriate strategy for this corridor.

Analysis and Conclusions Offered by Dr. Edward Fagen

Q. In the prefiled direct testimony of Dr. Edward Fagen for the Addison County Regional Planning Commission, Dr. Fagen concludes that reconductoring the 115 kV circuit from West Rutland to New Haven, instead of adding a new 345 kV circuit, would adequately serve Vermont's needs for statewide loads up to 1200 MW. Do you agree with Dr. Fagen's analysis and conclusions?

A. No. While Dr. Fagen properly recognizes that reconductoring[6] the 115 kV circuit from West Rutland to New Haven would increase this circuit's thermal capacity and

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[5]Town of New Haven's Motion for Partial Judgment as to the 345 kV Line and Substation, or if Judgment Is Denied, for an Order Conditioning Re-opening of Petitioner's Evidence upon Funding of Experts and Counsel to Respond to Re-opened Evidence dated March 8, 2004 and filed with the Public Service Board on March 9, 2004.

[6]Dr. Fagen focuses on a bundled, two conductors per phase, configuration.

reduce line losses, his analysis ignores two vital issues, namely contingency response and voltage drop effects.

With regard to contingency response, we note that the transmission system is in the form of a network. Following contingencies, power flows redistribute on the network in a manner that depends on individual line impedances and on the characteristics of the contingency itself. Simply adding thermal capacity to one line, as is suggested by Dr. Fagen's alternative, does not address the manifold situations arising from the multitude of possible contingencies. For Dr. Fagen's approach to be effective in avoiding overloading other lines, the power flow increases resulting from all possible contingencies would have to be "directed" to the West Rutland to New Haven path where the thermal capacity increase, through reconductoring, was realized. Transmission networks simply do not work in this manner. As a result, we believe that adoption of Dr. Fagen's proposal would result in post-contingency line overloads and serious degradation to system reliability.

With regard to voltage drop effects, it is imperative that a transmission system maintain adequate voltages following contingencies. Line voltages, post-contingency, are directly related to the level of reactive losses that appear on lines as a result of increased post-contingency power flows. For Dr. Fagen's proposal to work, the inductive reactance of the reconductored line would have to be low enough to maintain acceptable reactive losses under all contingencies. However, while the *resistance* of the reconductored line would be reduced by doubling the conductor, the *inductive reactance* of the line (the component of line impedance primarily responsible for voltage drops), would not be significantly reduced by reconductoring. Specifically, the double-conductor, single-circuit configuration considered by Dr. Fagen would only reduce the inductive reactance by approximately 20% to 30%. By comparison, upgrading this circuit to 345 kV would reduce the inductive reactance by approximately 90%. It is this significant reduction in inductive reactance that would allow this line to maintain adequate post-contingency voltages because post-contingency voltage drops on a transmission line, in large part, are a function of the line's inductive reactance.

Q. Is there another way to view the analysis offered by Dr. Fagen?

A. Yes. Consider the alternate configuration studied by VELCO in which a second 115 kV circuit from West Rutland to New Haven is constructed rather than the proposed 345 kV circuit. (See VELCO Exhibit Planning - 8.) For this configuration, the inductive reactance from West Rutland to New Haven would be reduced by 50%. In order to meet voltage performance requirements, this strategy would require an *additional* 115 kV circuit from Granite to Middlesex. The estimated cost of this alternate configuration would be higher than that of the proposed NRP. Since Dr. Fagen's proposed configuration offers even less of a reduction in inductive reactance than does this alternate studied by VELCO, we conclude that *even if* Dr. Fagen's proposal could be made to work,[7] then even more system reinforcements would be required, at added cost.

Q. Would there be any other consequences to the adoption of Dr. Fagen's reconductoring strategy?

A. Yes. Adoption of a strategy in which the West Rutland to New Haven 115 kV line is reconductored would result in the loss of the platform, provided by the proposed 345 kV line, for future load serving capability in the state. This is discussed in the direct testimony of George E. Smith in this proceeding.

The PV 20 Failures of April 2004

Q. In the direct testimony of VELCO witness Gary A. Parker in this proceeding, Mr. Parker lists and discusses a number of transmission system contingencies that have affected the VELCO system from 1994 to April 2003. Are you aware of contingencies that have affected the VELCO system since the time of the filing of Mr. Parker's testimony?

A. Yes. In addition to the events of January 16, 2004,[8] in April 2004, the 115 kV line

[7]For the reasons described above, we do not believe that Dr. Fagen's proposed strategy is viable.

[8]The system contingencies of January 16, 2004 and their significance were addressed during examination of VELCO witness Tom Dunn. 2/20/04 tr. at 150-51 (Dunn).

between Plattsburgh, New York and Milton, Vermont, known as the PV 20 line, experienced two failures. On April 12, 2004, a wild fire occurred beneath the PV 20 line in South Hero, Vermont which required VELCO operators to remove the line from service so that the local fire department could extinguish the blaze. Damage resulted to one structure on this line. On April 16, 2004, the PV 20 line experienced an outage resulting from human error, specifically, a mistakenly sent transfer-trip signal that resulted in removal of the PV 20 line from service.

Q. Did these incidents result in a loss of load?

A. No. These two incidents occurred at a time when system loads were relatively light, as is the norm for spring and fall periods, and at a time when the system was not affected by other contingencies. As a result, the VELCO system was able to continue to serve all load following these contingencies.

Q. What do you believe is the significance of these two events?

A. From our perspective, these two events serve as a reminder that transmission system contingencies do in fact occur without warning. Also, these contingencies occurred on the PV 20 line, one of the two most important transmission links into northwest Vermont. Had these contingencies occurred under different circumstances, say when loads were higher and other contingencies (in particular, an outage of the Highgate converter) had impacted the system, the effects could have been much more severe including the loss of load and/or possibly voltage collapse. We believe that these events further underscore the need for transmission system improvements to the VELCO system.

Comments on the Supplemental Direct Testimony of Gail Henderson-King

Q. Do you have any comments with respect to Exhibit 16, pages 1 and 4, attached to the supplemental direct testimony of Gail Henderson-King, a witness for the Town of Shelburne?

A. Yes. We believe that the facilities shown on page 1 of that exhibit are 34.5 kV rather than 115 kV as labeled. We also believe that the facilities shown on page 4 of that exhibit are 115 kV rather than 345 kV as labeled.

Board Record Requests of June 22, 2004

Q. In its memorandum of June 22, 2004, the Board issued the following request, #2:

> If any section of the 115kV line from New Haven to Queen City is buried, and there is a fault in the buried cable, will any of the customers experience an outage (other than the initial event and required switching) to their service while the fault is being located and repaired? Would the answer to this question be any different for overhead lines?

What is your response to this request?

A. If there is a fault in the cable section as described, and there is only one cable section between circuit breakers,[9] the only outage that customers would experience would be during the required switching procedures. The duration of the outage, however, can differ from that of an overhead line. Specifically, in the event of a temporary fault,[10] an overhead line would be cleared by circuit breakers and service restored, automatically, in a matter of a few seconds. However, in the situation in which the line contains a cable section, automatic reclosing on this line section generally would not be allowed. Therefore, in the event of a temporary fault on a line containing a cable section, regardless of whether the temporary fault is on an underground or overhead section, the required switching procedures, which would employ remote control (SCADA) and motorized disconnect switches, would require a longer time period, most likely on the order of minutes to accomplish.

In the event that there is more than one underground section between circuit breakers, and there is a substation located between the underground sections, outages to the substation could be lengthy. For example, consider a hypothetical situation in which there is an underground section south of the Charlotte substation and another underground section located between the Charlotte substation and the Shelburne substation. In the event of a

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[9]The reroute proposal places circuit breakers on the 115kV line at New Haven, Vergennes, and Queen City.

[10]Approximately two-thirds of all transmission faults are temporary faults.

fault on one of these underground sections, breakers at Vergennes and Queen City would open and not reclose. Following breaker operation, remote switching and line testing by VELCO operators would likely restore the North Ferrisburg and Shelburne substations within minutes. However, service to the Charlotte substation customers likely would be lost for several hours until the faulted cable section could be located and the required restoration switching performed.

Q. In its memorandum of June 22, 2004, the Board issued the following request, #5:

> Has the passage of time, or additional information, revealed any basis for reconsideration of the analyses presented by the Planning Panel on pages 33-34 of their June 5, 2003, testimony and by Mr. Smith on pages 17 through 20 of his December 17, 2003, testimony in regard to installation of a second 115 kV line within the existing VELCO 115 kV corridor (in Monkton, Hinesburg, St. George, and Williston) between New Haven and Queen City via the VELCO Williston substation?

What is your response to this request?

A. No. The only new information that we are aware that could impact the analyses would be the changes brought about by the proposed reroute. Neither these changes, nor the passage of time, reveals any basis for reconsideration of the analyses on this issue.

Other Board Inquiries

Q. The Board has inquired about the use of non-specular conductor as one means of mitigating the visual impact of newly installed overhead transmission lines. What is your view of this application?

A. Non-specular conductor is available from the major manufacturers of aerial bare conductor. The non-specular properties of the conductor are obtained by utilizing an acid wash after stranding. This process accelerates the dulling of the conductor finish which is otherwise caused by exposure to the elements in the first year or two after installation. There appear to be no problems with the installation, operation, maintenance or life span of the non-specular conductor. According to Alcan, a major conductor manufacturer, the estimated cost premium for non-specular conductor ranges from of 2% to 3%, depending on conductor size.

Q. The Board has expressed an interest in the application of Gas Insulated Substation (GIS) technology for the purpose of enclosing substations within structures in order to minimize the footprint and visual impact of substations. What is your view on the application of this technology?

A. Based on a limited review, it appears that the 115 kV switching equipment and buswork can be substantially reduced in size using GIS technology. For an electrical configuration similar to that proposed for the Charlotte substation, this 115 kV GIS equipment, the 115kV/13.2 kV transformer, the low voltage circuit breakers, and the relay and control equipment all could be housed in an enclosed building. The building could take on the appearance of a barn or some other type of structure suitable for the surroundings. It should be noted that termination of the 115 kV lines near the building (referred to as "dead ending") would still require either vertical single pole or A-frame dead-end structures located outside of the building. The building structure may require a footprint of 40 ft. by 100 ft. and a height on the order of 45 ft. Assuming a structure cost on the order of $150 per sq. ft., the 4,000 sq. ft. building would cost approximately $600,000. Adding a cost premium associated with the GIS technology, and deducting the original proposed control building cost, the result is an overall cost adder of approximately $900,000 for the fully enclosed substation configuration. When added to the $2,000,000 estimate for the air insulated configuration proposed by VELCO, we arrive at a total cost of $2,900,000.[11] The $2,000,000 VELCO estimate did not include land acquisition cost. Depending on local zoning requirements associated with building setbacks and other factors, the application of GIS technology may result in some savings in land acquisition. Technical challenges regarding the need to cool the 115/13.2 kV transformer would need to be addressed. Also, 115 kV load break disconnect switches apparently are not available with GIS, so circuit breakers would have to be substituted for the motor operated disconnects proposed in the VELCO design. The use of circuit breakers rather than disconnect switches would result in improved automatic sectionalizing for 115 kV line faults. While our review did not reveal

[11]This preliminary cost estimate applies only to the proposed Charlotte substation. The cost of applying GIS technology to other substations likely would vary.

any “show-stoppers” from an operations perspective, we emphasize that this review is only preliminary and would need to be followed by a more comprehensive engineering study before employing this technology at a specific location.

Q. Does this conclude your rebuttal testimony?

A. Yes.